アジア・モンスーン地域の建築環境検討小委員会

Urban Climate Challenges in Growing Cities of Southeast Asia

2017年6月28日

広島大学大学院国際協力研究科
久保田　徹

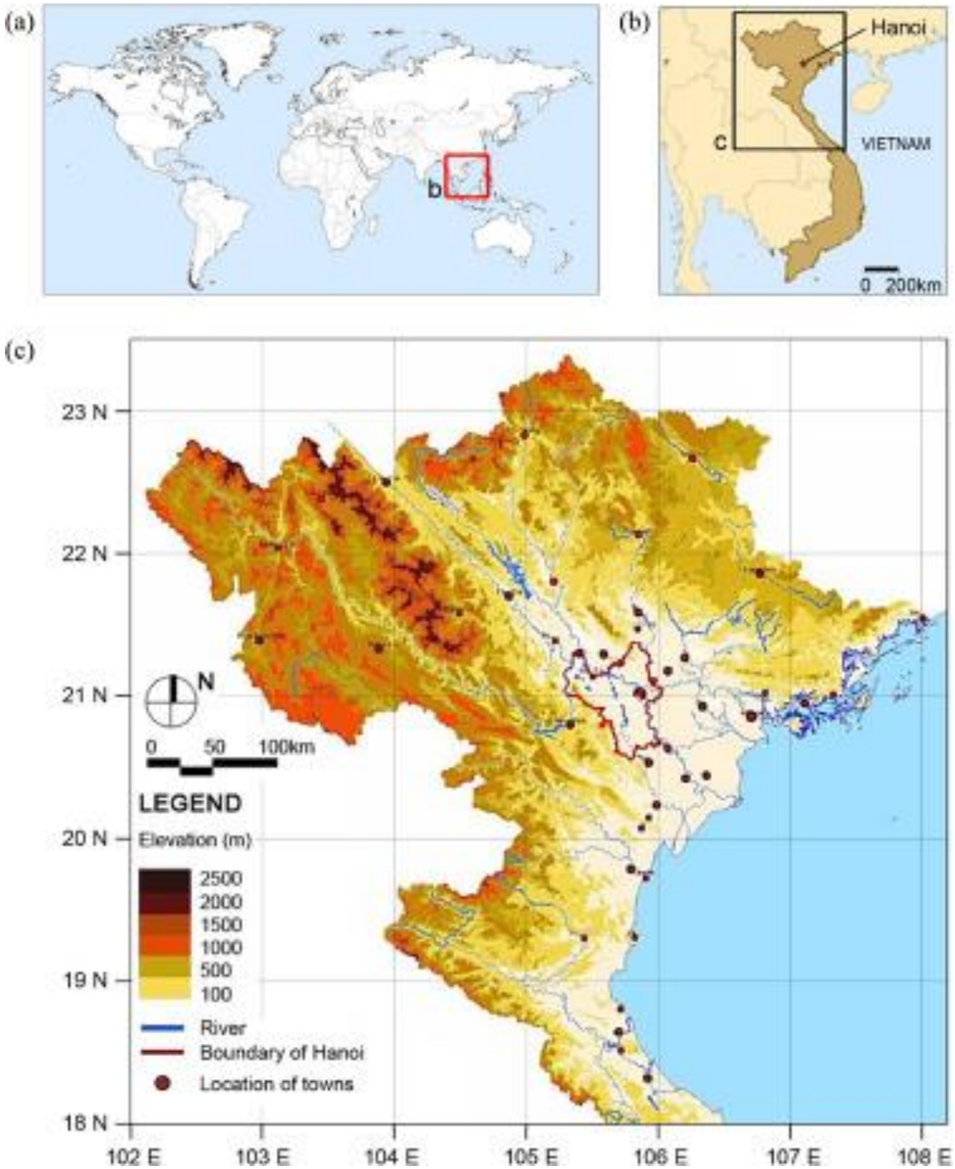


Fig. 2. Series of maps showing (a) location of Vietnam, (b) Hanoi City in Vietnam, and (c) elevation map.

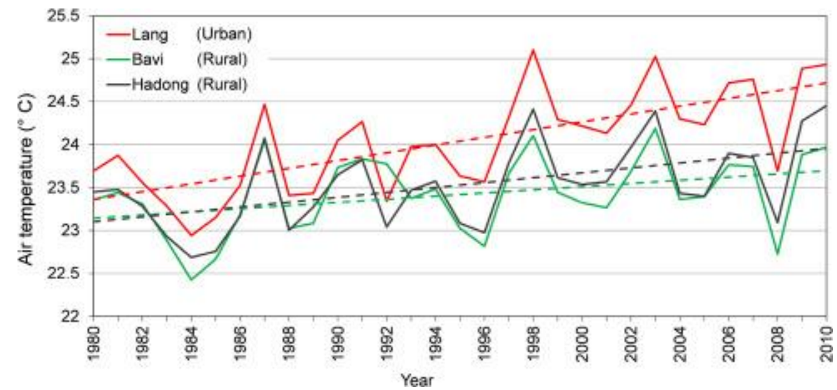
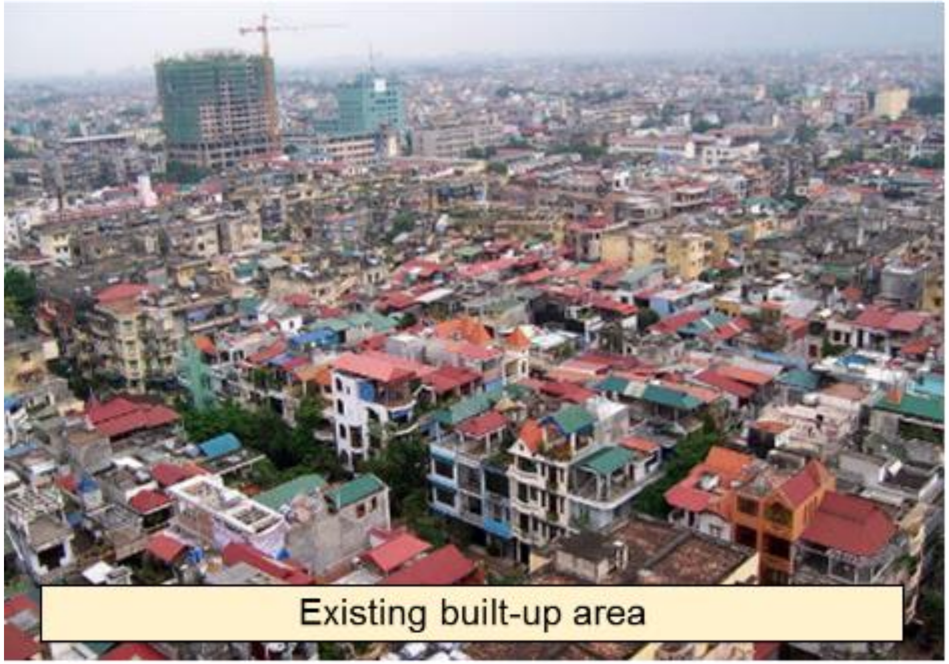
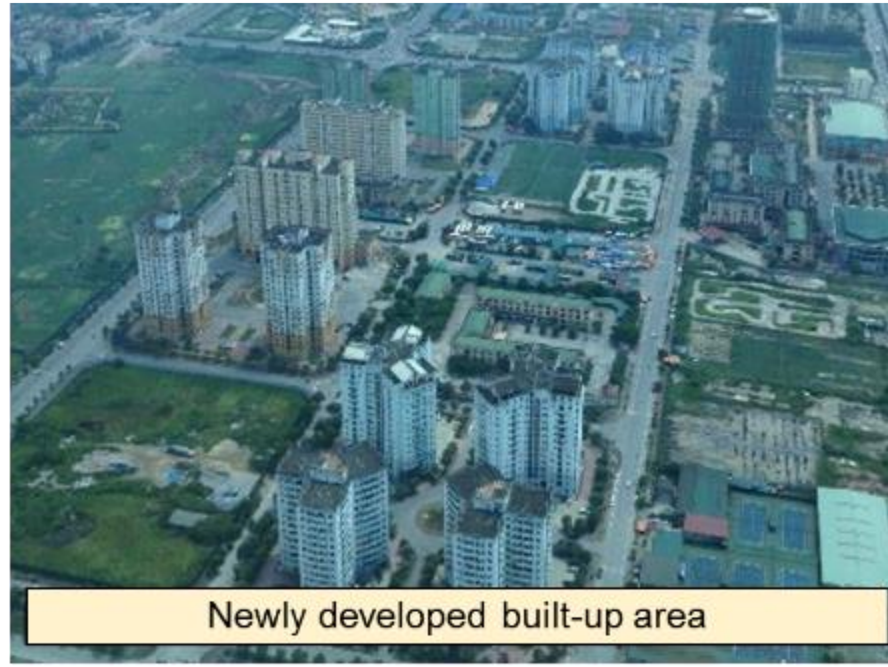
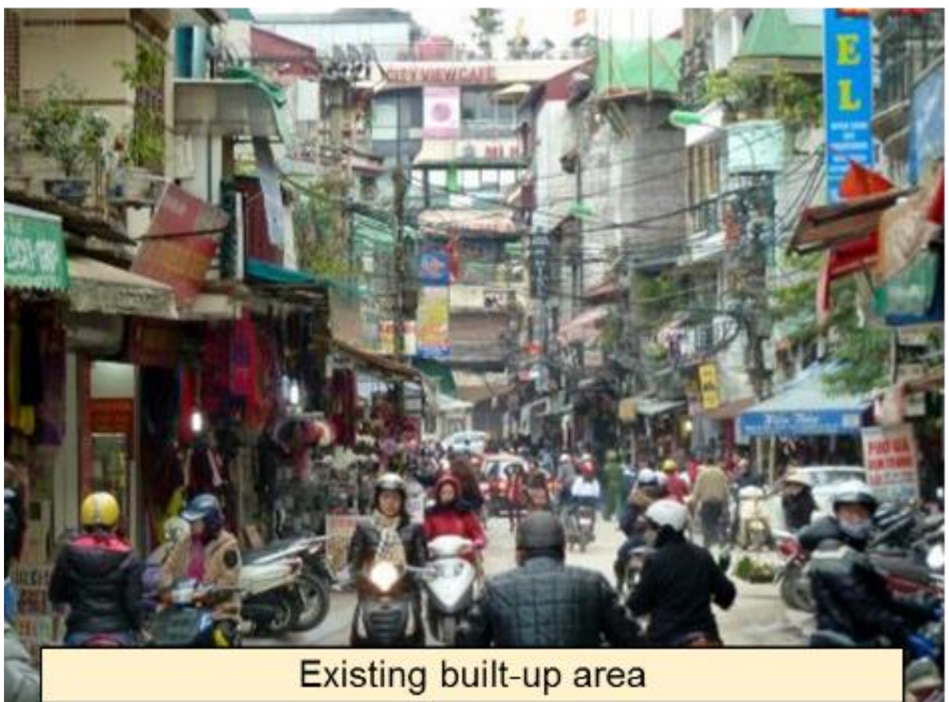


Fig. 1. Air temperature records in Hanoi City from 1980 to 2010 exhibit the gradual increments.

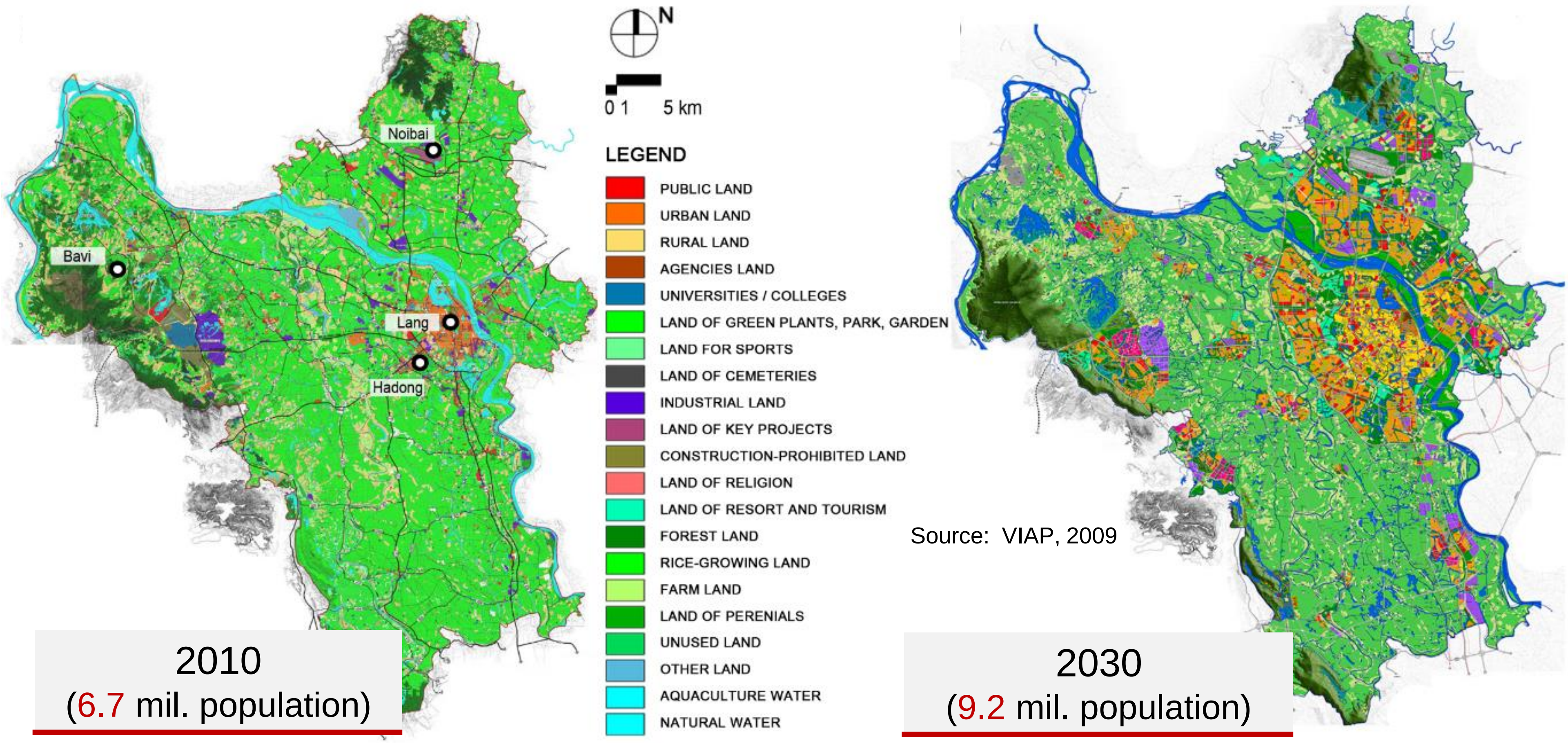

Existing built-up area


Newly developed built-up area


Existing built-up area


Newly developed built-up area

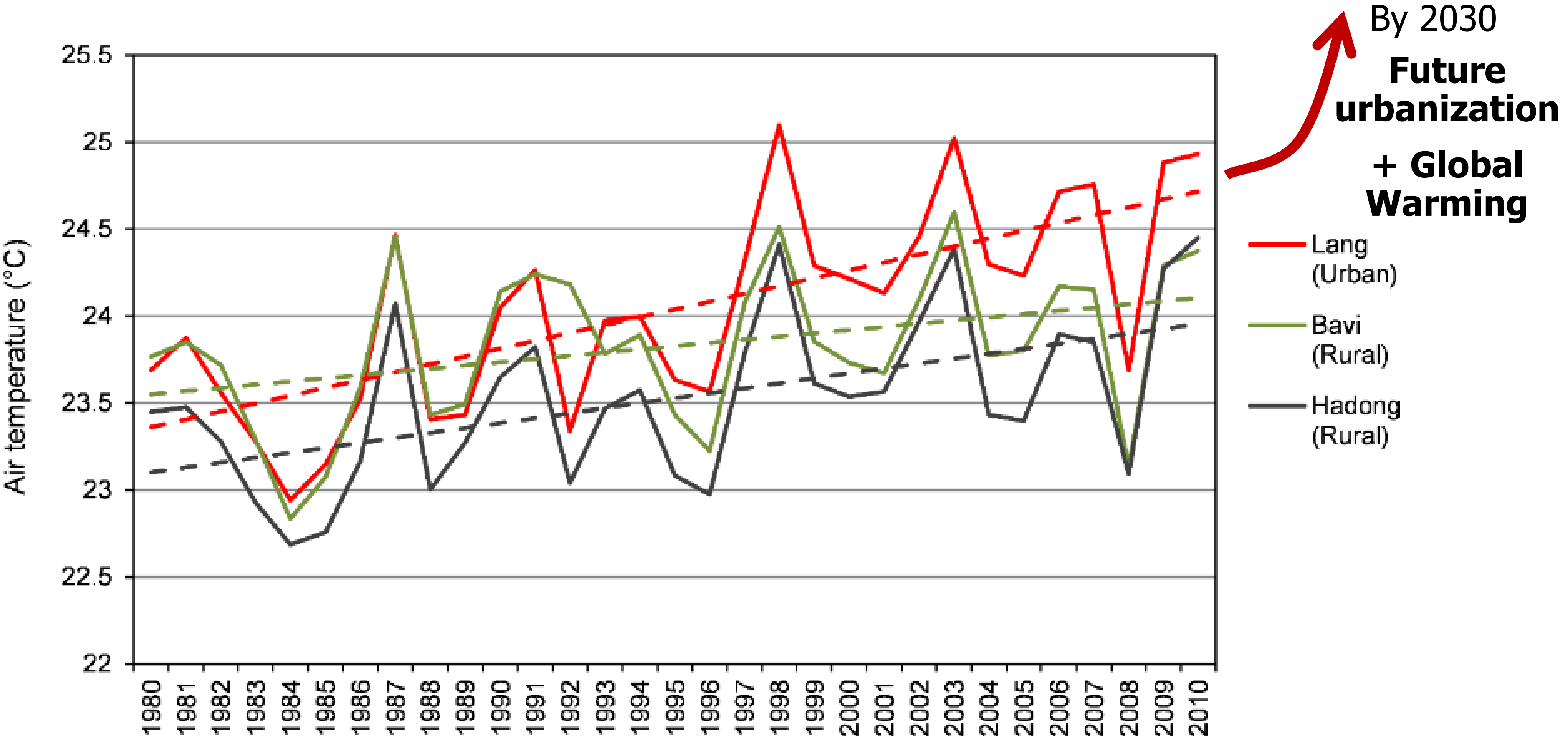
Urban development plan in Hanoi, Vietnam



- Around 90,000 ha agricultural land will be turned into land for new constructions.
- The Hanoi Master Plan 2030 is expected to alter the urban climate in the future.

What will become of the future Hanoi City?

?

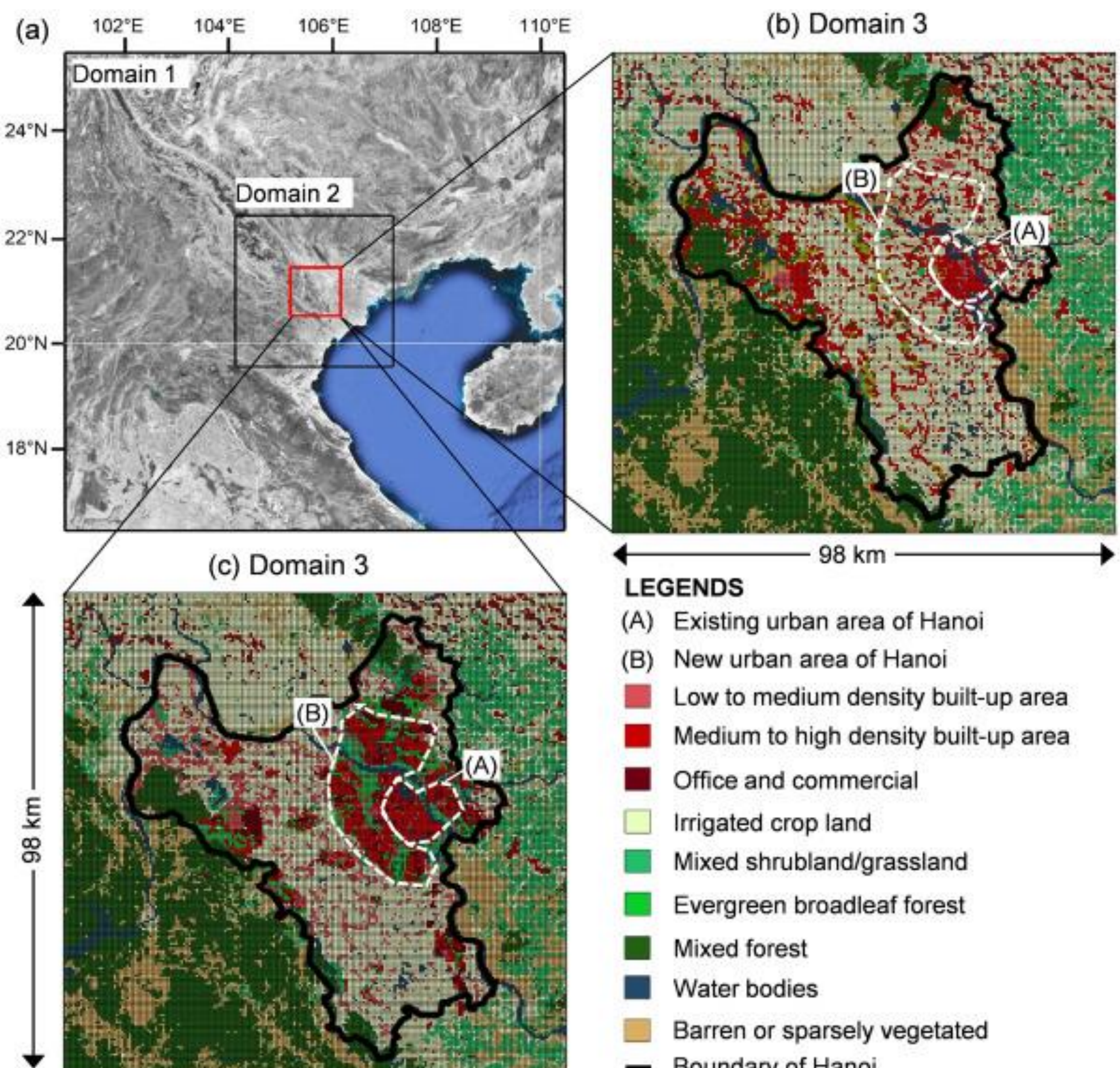


- How much temperature will be increased?
- How much energy will be additionally required, especially for cooling?

熱帯地域における都市の暑熱化

- 年間を通じて冷房負荷を大きく増加させ，都市のエネルギー消費量の増大を招く。
- 室内，屋外の熱ストレスを高める。熱中症や睡眠障害等の健康被害の増大。さらに，熱的快適性への影響。
- 熱帯性感染症の増大？（特に，蚊媒介感染症）
- 大気汚染の悪化

→ 熱帯の都市暑熱化は悪影響のみ
→ 熱帯新興国のUHI研究は比較的少ない



(a)
102°E
104°E
106°E
108°E
110°E
24°N
22°N
20°N
18°N
Domain 1
Domain 2
(b) Domain 3
(B)
(A)
98 km
(c) Domain 3
98 km
LEGENDS
(A) Existing urban area of Hanoi
(B) New urban area of Hanoi
Low to medium density built-up area
Medium to high density built-up area
Office and commercial
Irrigated crop land
Mixed shrubland/grassland
Evergreen broadleaf forest
Mixed forest
Water bodies
Barren or sparsely vegetated
Boundary of Hanoi

Table. Domain sizes, resolutions, physics and parameterizations used in the WRF simulation.

Physics /parameterisations	**Domain 1**	**Domain 2**	**Domain 3**
Horizontal resolution (km)	4.5	1.5	0.5
Domain size (km)	990 × 990	312 × 312	98 × 98
Land use and land cover	USGS (default)	USGS (default)	Landsat 8 imagery combined with digital land use data
Vertical layers	30		
Microphysics	WRF single-moment 3-class scheme		
Longwave radiation	Rapid Radiative Transfer Model (RRTM) scheme		
Shortwave radiation	Dudhia scheme		
Surface-layer	Monin–Obukhov similarity scheme		
Land surface model	Noah Land Surface Model (LSM) and Single layer Urban Canopy Model (UCM) with default parameterisations		
Planetary boundary layer	Yonsei University (YSU) Scheme		
Simulation period	00:00 UTC 12 to 00:00 UTC 24 June 2013 (for validation purpose)		

Summary of scenarios for numerical experiments

	Land use and land cover conditions	Global warming effects	Initial and boundary weather conditions
Case 1 (base case)	Current (2010)	×	Current (June 2013)
Case 2–1	Future master plan (2030)	×	Current (June 2013)
Case 2–2	Future master plan (2030)	○ (RCP 4.5)	2030s (June 2026–2035)
Case 2–3	Future master plan (2030)	○ (RCP 8.5)	2030s (June 2026–2035)

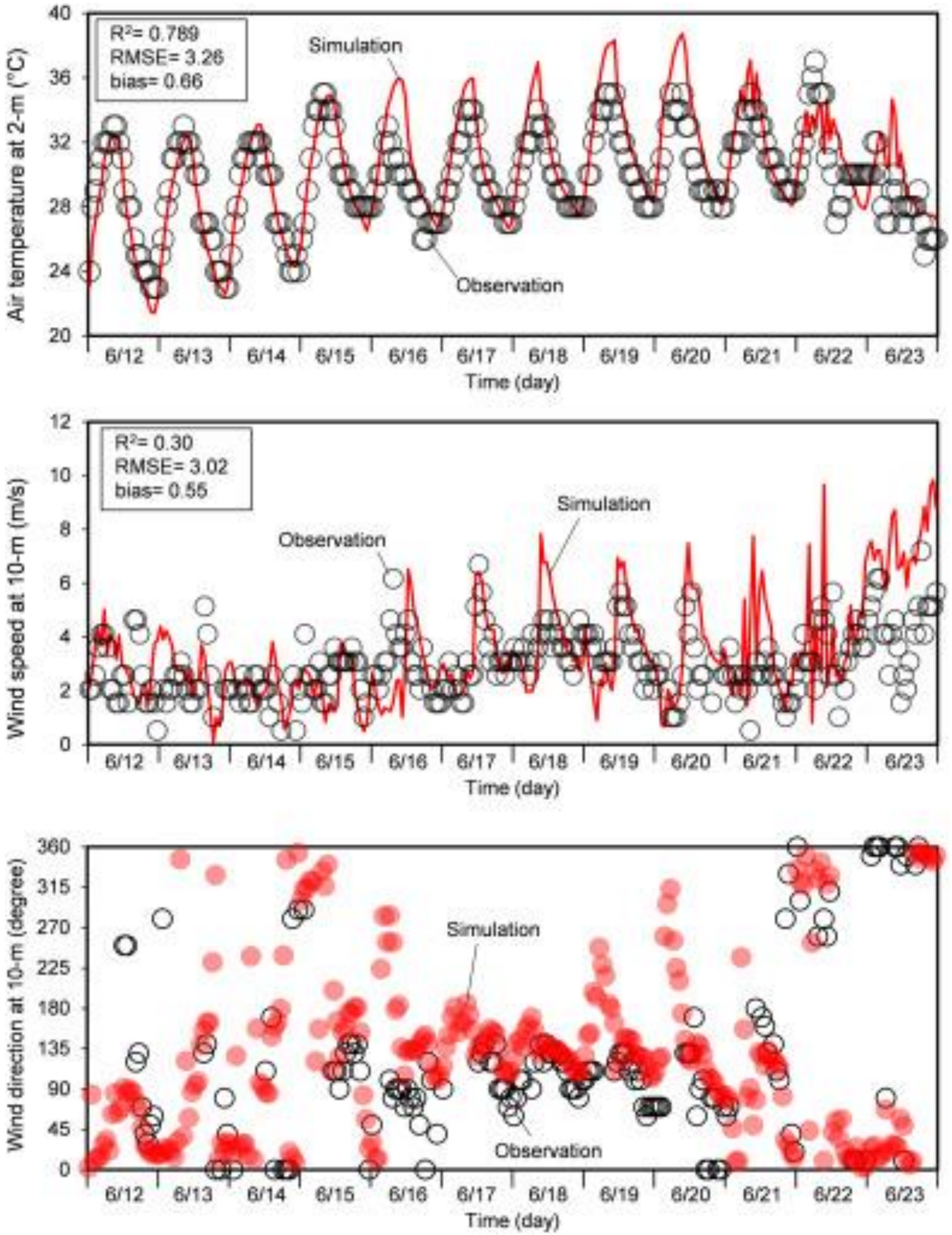
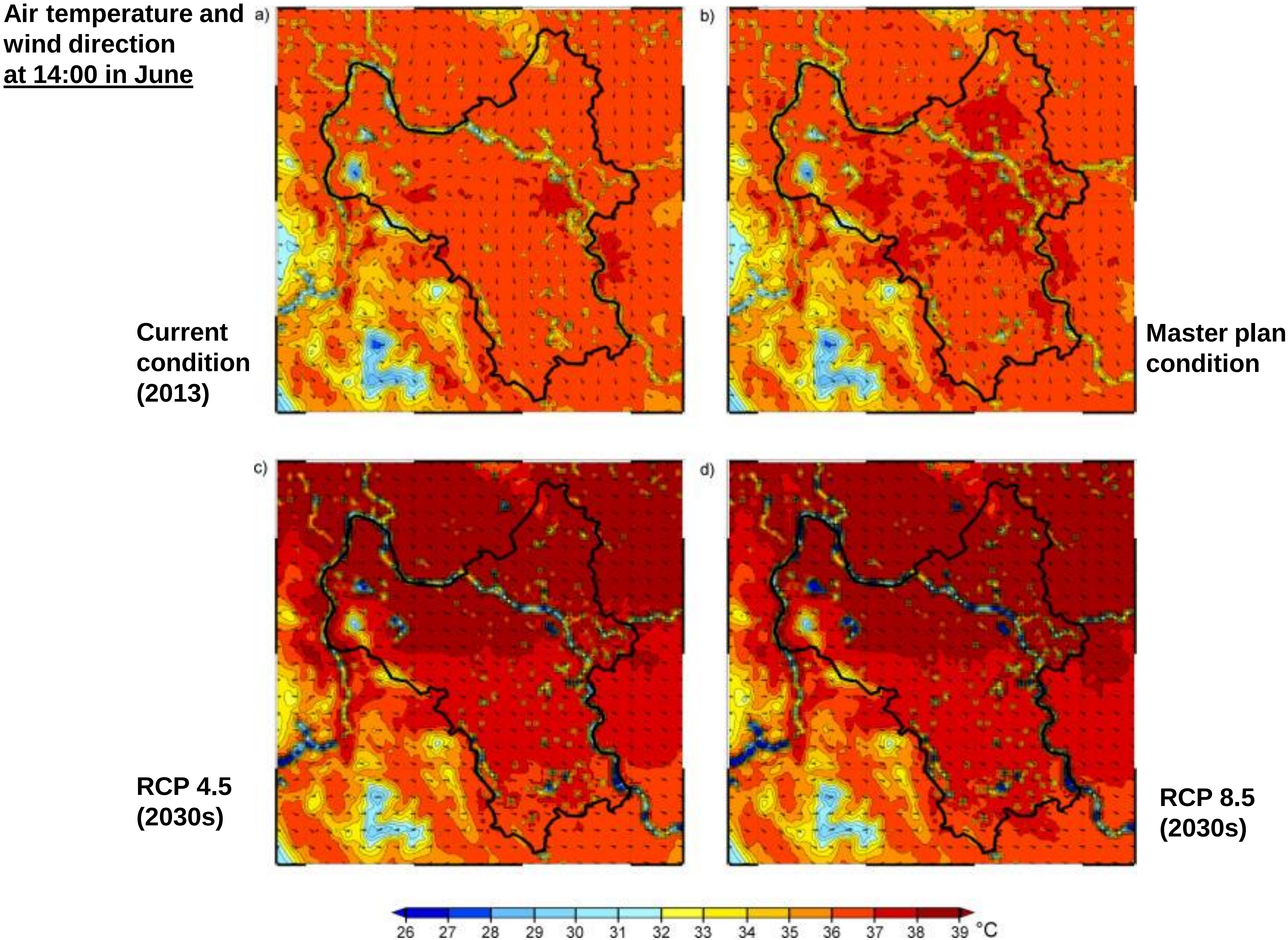
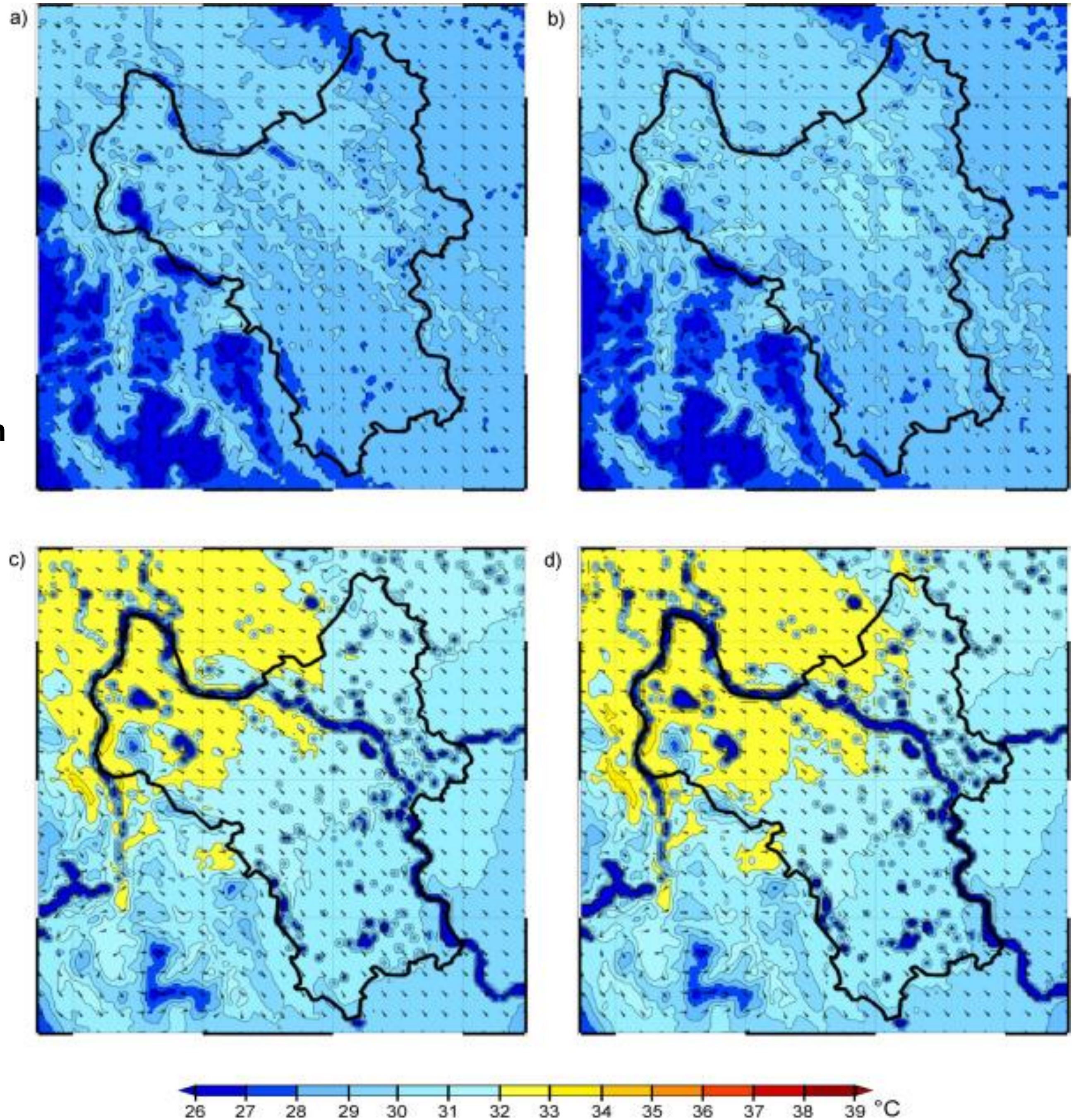


Fig. 4. Comparisons between observed (blank dots) and simulated air temperature (red line), wind speed (red line) and direction (red dots) at Noibai weather station, 21.22° N and 105.8072° E.


Air temperature and
wind direction
at 14:00 in June
a)
b)
Current
condition
(2013)
Master plan
condition
c)
d)
RCP 4.5
(2030s)
RCP 8.5
(2030s)
26
27
28
29
30
31
32
33
34
35
36
37
38
39
°C

Air temperature and wind direction
<u>at 1:00 in June</u>



Current condition (2013)

Master plan condition

RCP 4.5 (2030s)

RCP 8.5 (2030s)

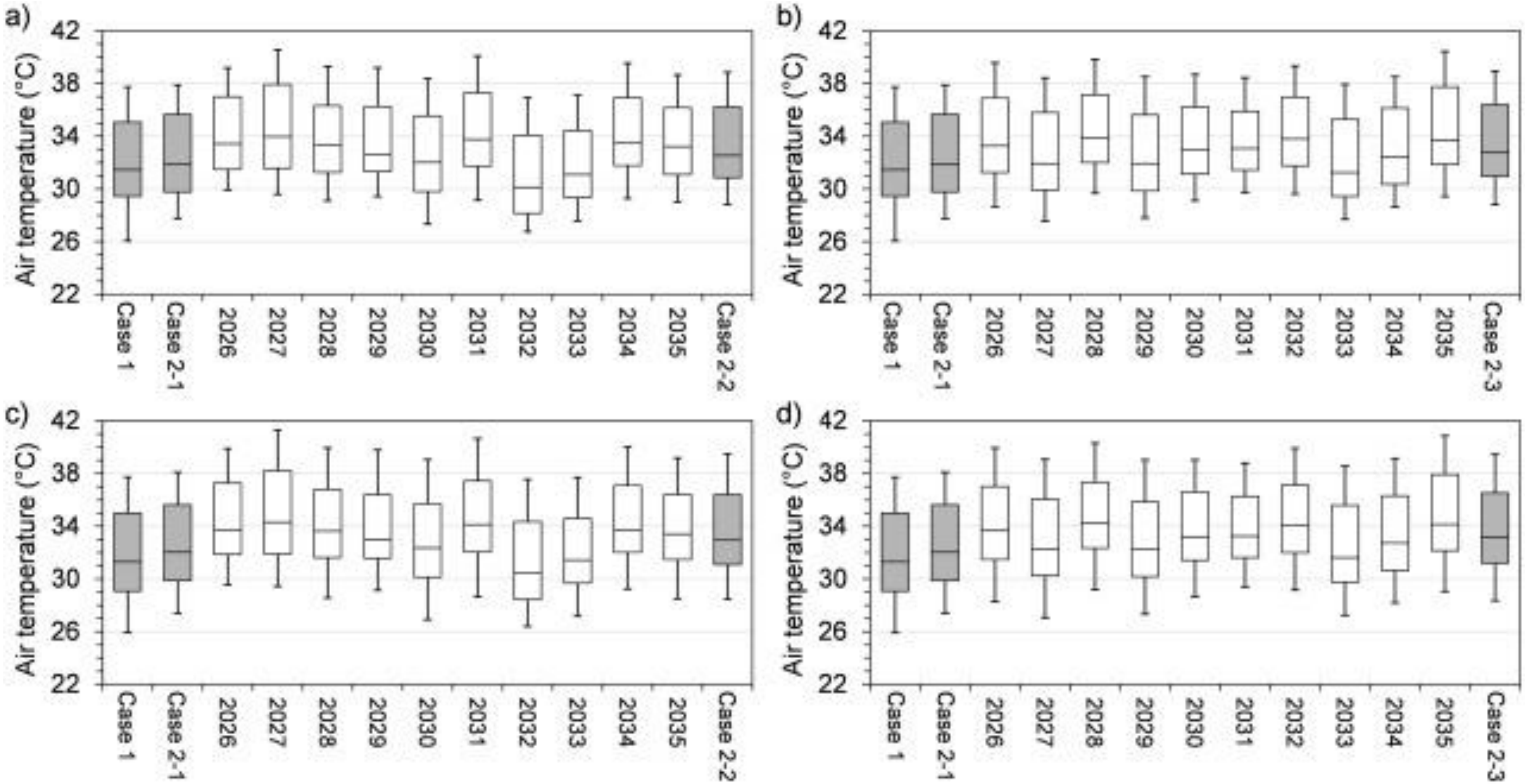
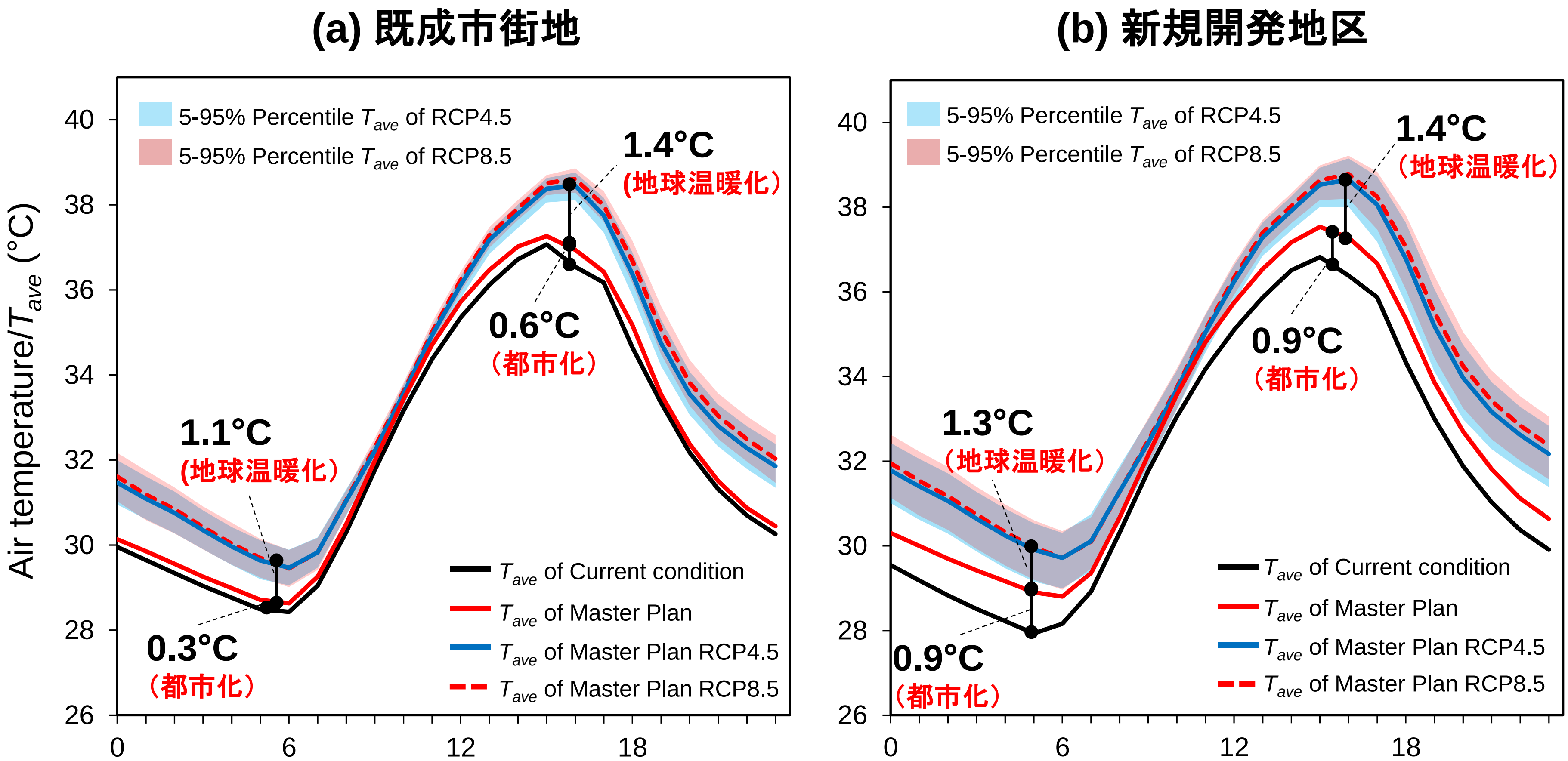


Fig. 8. Statistical summary (maximum, minimum, 25th percentiles, 75th percentiles, and median) of average air temperature in the existing urban area for (a) RCP4.5, (b) RCP8.5, and at the new urban area for (c) RCP4.5 and (d) RCP8.5.

ハノイの都市気候の将来予測：日変化



ハノイの既成市街地と新規開発地区における平均気温の将来予測（2010年→2030年）

- ハノイの既成市街地の夏季のピーク気温は2030年までに約2.0℃上昇する。
- そのうちの1.4℃（70%）は地球温暖化による影響

得られた主な知見

1. ハノイでは，都市マスタープラン実現によって，特に夜間の高温域（Hotspots）は大きく拡大する（面的に23%まで拡大）。
2. 2030年代までの都市化（土地利用の変化）に伴う気温上昇は，既成市街地で平均約0.6℃，新規開発地区で約1℃。
3. ハノイの夏季の気温は，地球温暖化の影響によって2030年代までに大きく上昇する。
4. 既成市街地においては平均で約2.1℃の上昇が見込まれ，そのうちの1.5℃（71%）は地球温暖化による影響で，残りの0.6℃（29%）は都市化による影響と予測された。

→　特に既成市街地では，Adaptation≫Mitigationか？

Impacts of Urban Warming on Indoor Thermal Comfort and Cooling Load in Urban Houses for the 2030s:
A case study of Hanoi, Vietnam

Simulation conditions

Figure. Exterior view of the case study house

Orientation: North
Total floor: 295.2㎡
Material: Hole-burned bricks

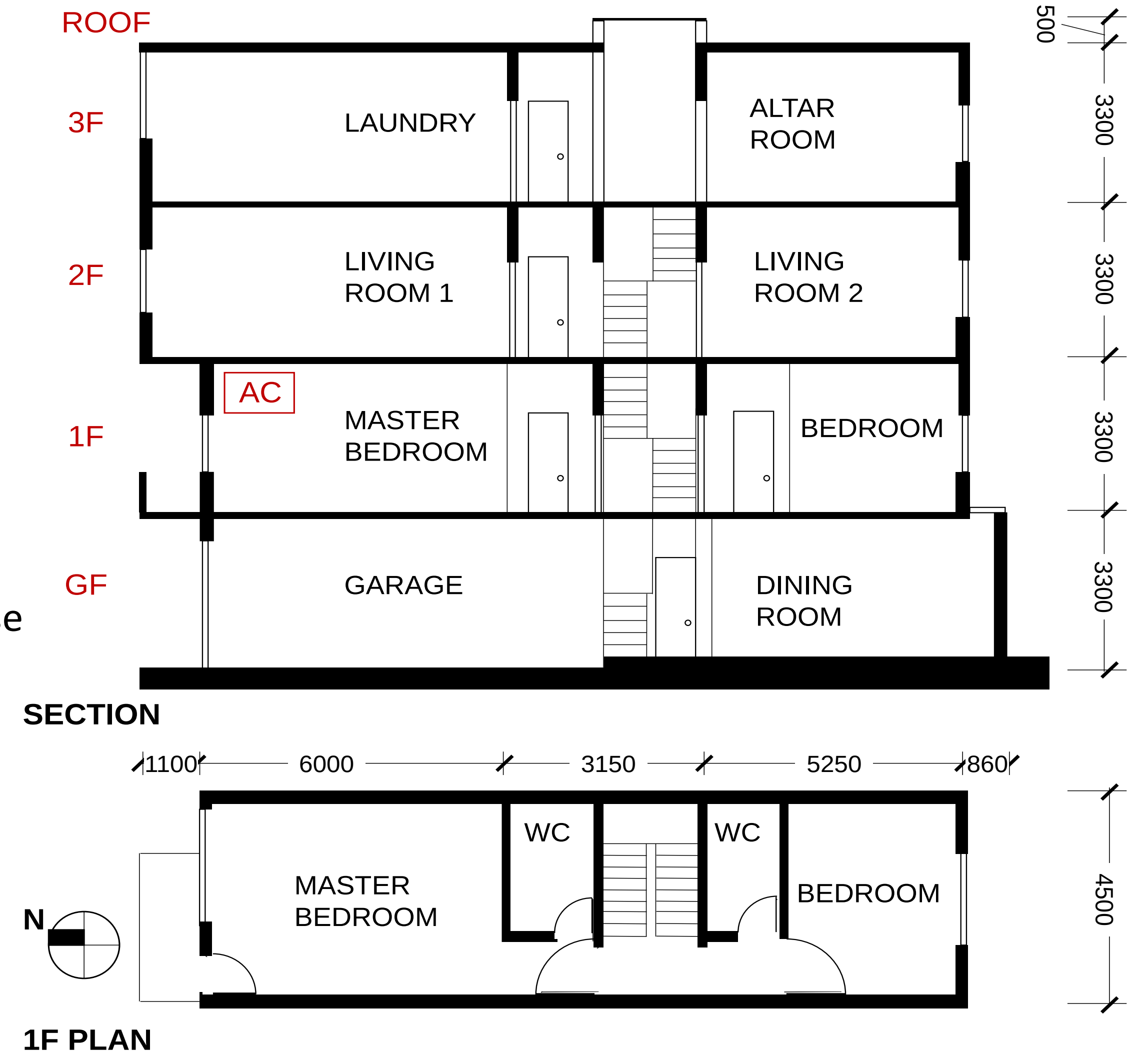


Figure. Floor plan and cross section of case study house

Validation for the simulation model

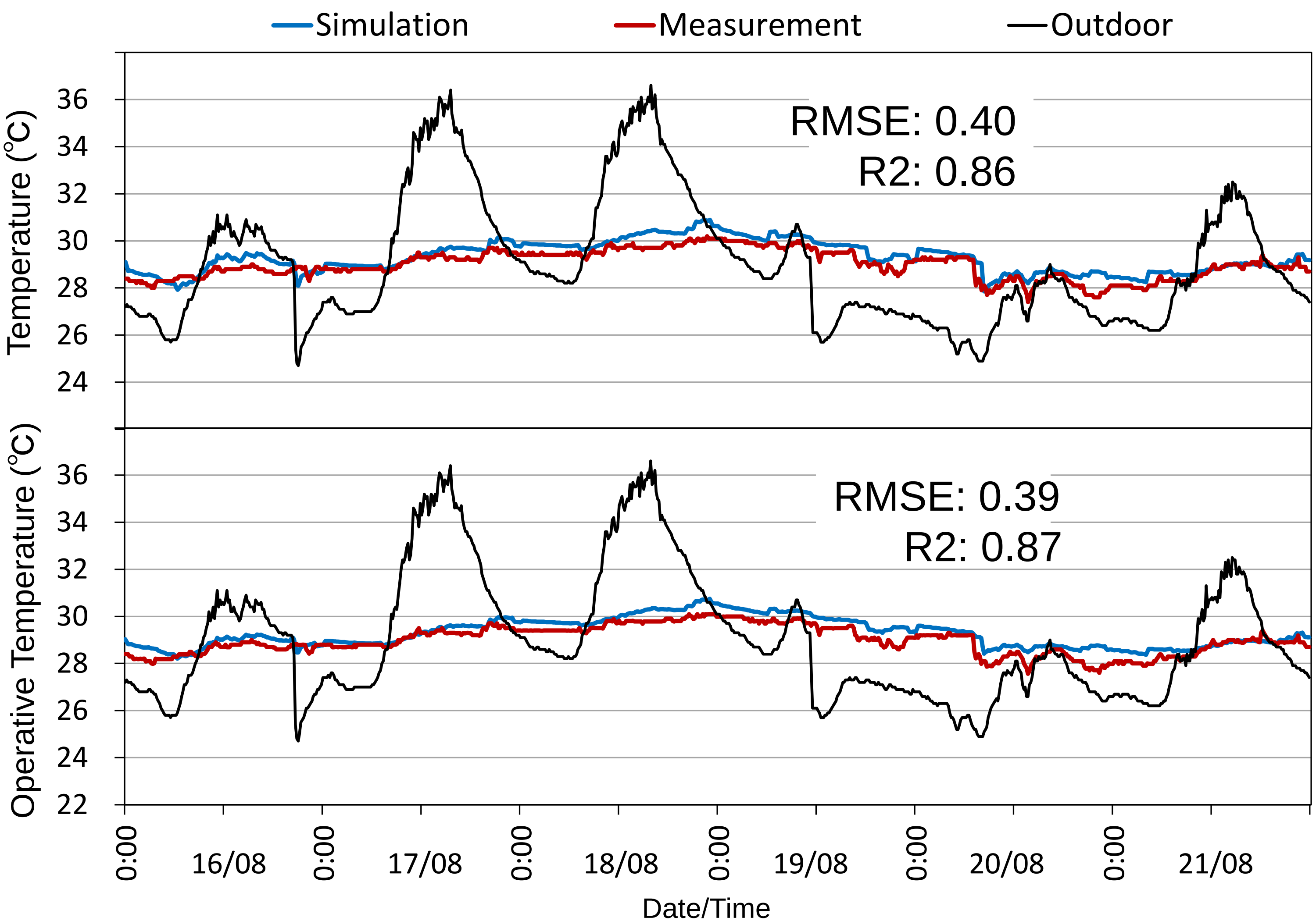


Figure. Temporal variations of simulated data in the master bedroom compared to the field measurement data from 16th to 21th August

Results:

Impacts of ventilation techniques on the indoor thermal comfort

Current condition (June 2013)

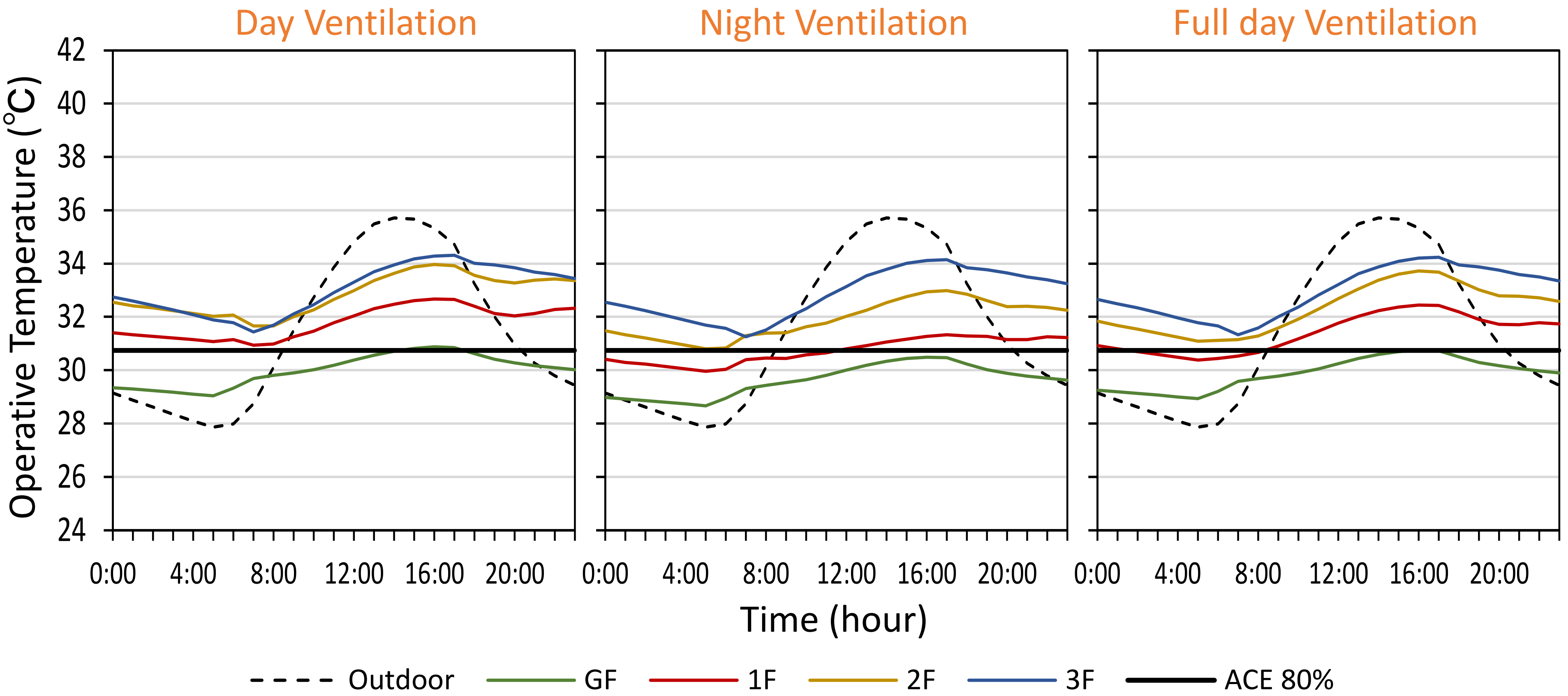


Figure. Outdoor and indoor operative temperatures for each floor for existing urban area in current condition

Results:

Impacts of ventilation techniques on the indoor thermal comfort

Future condition (2030s) in existing urban area

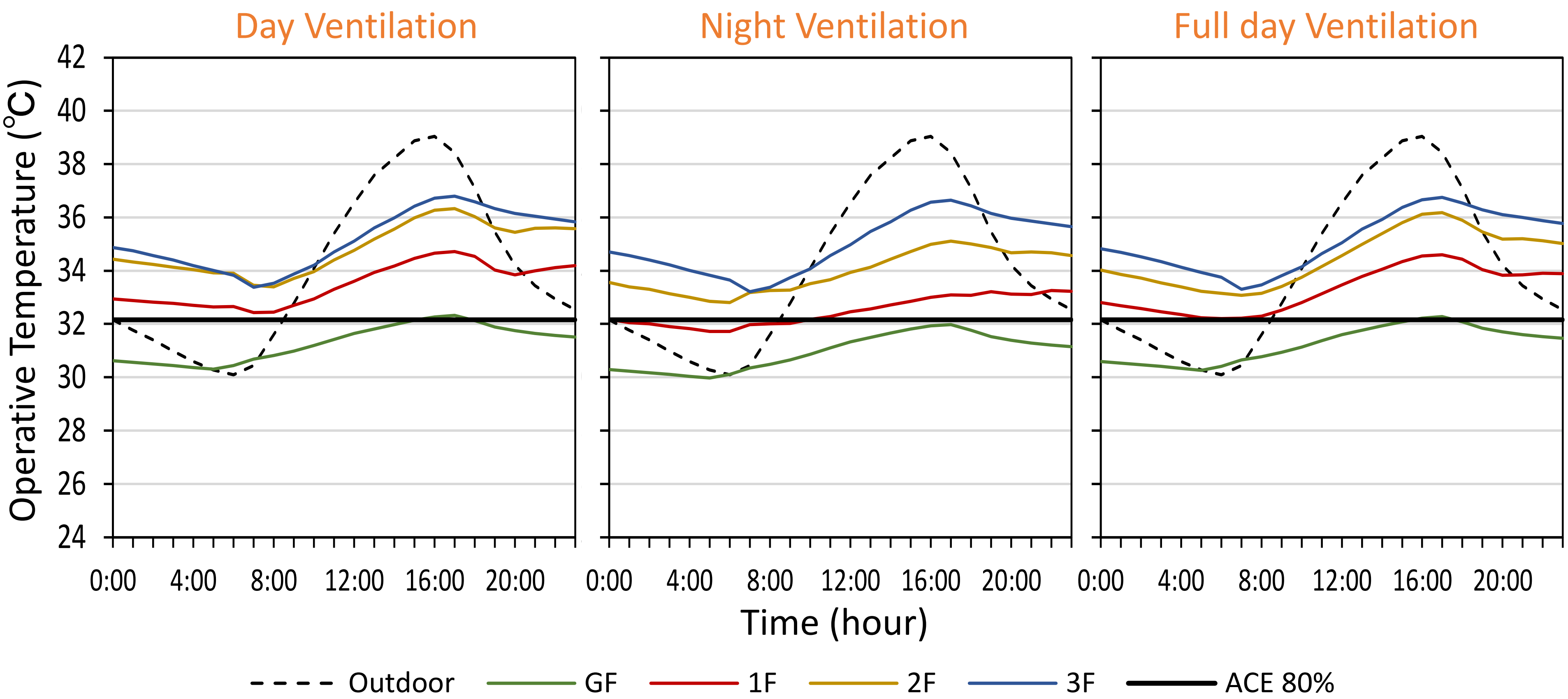


Figure. Outdoor and indoor operative temperatures for each floor for existing urban area in future condition

Results:

Impacts of ventilation techniques on the indoor thermal comfort

Future condition (2030s) in new urban area

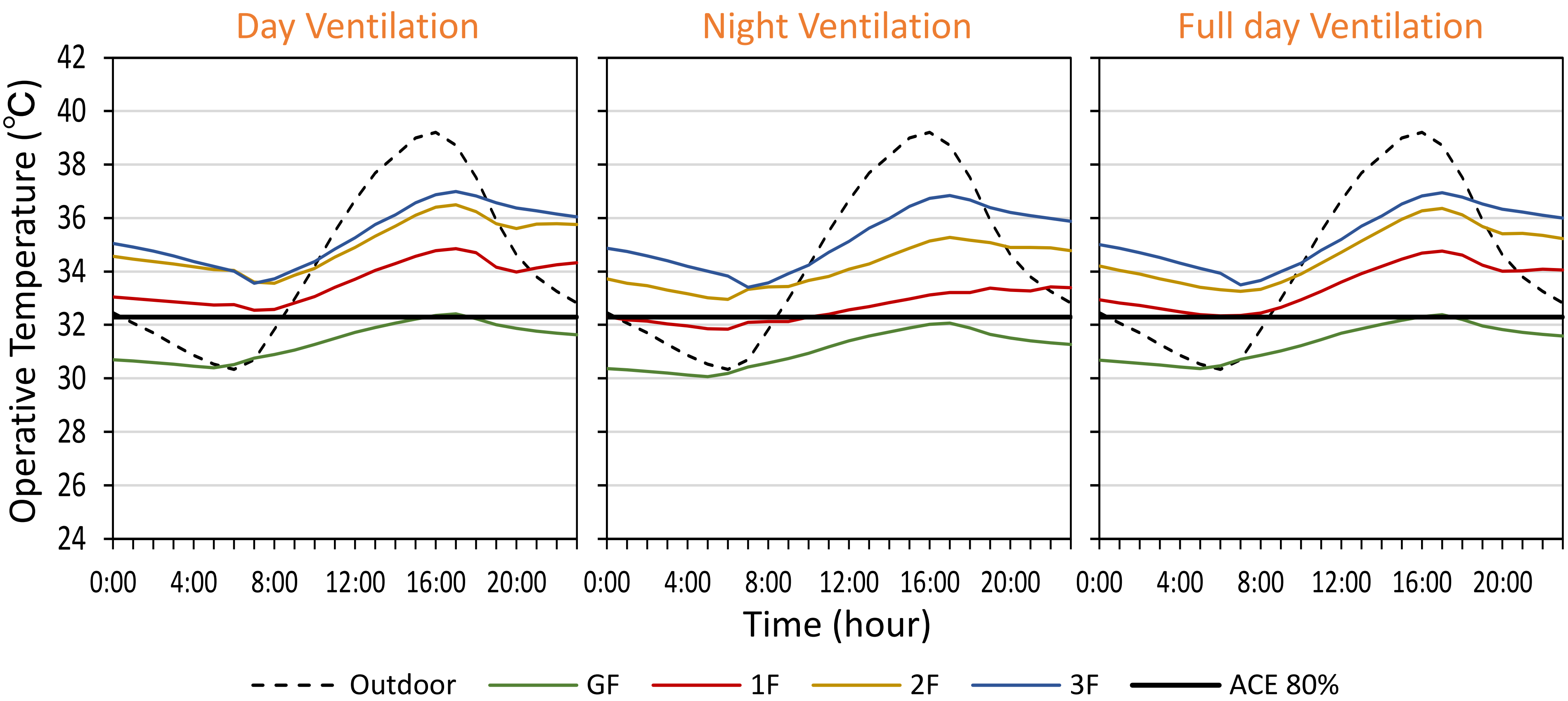


Figure. Outdoor and indoor operative temperatures for each floor for new urban area in future condition

Pre-summary

- Night ventilation gives the largest reduction of operative temperature in current and future conditions.

- In the future climate, the exceeding period will increase even when the night ventilation is employed.

It is necessary to employ green building techniques

- to reduce the indoor temperature under naturally ventilated conditions
- to reduce the cooling load of AC

Parametric study of green building techniques

6 green building techniques are proposed and assessed under four levels.
The techniques are based on LOTUS (i.e. the green building rating in Vietnam).

Parameter		Level 0 (base)	Level 1 (low)	Level 2 (middle)	Level 3 (recommendation)	Level 4 (high)
A: Cool roof	Albedo	0.3	0.5	0.6	0.7	0.9
B: Roof Insulation	Thickness (mm)	0	20	30	40	50
	U-Value (W/m2K)	2.00	0.94	0.75	0.62	0.53
C: External Insulation	Thickness (mm)	0	20	30	40	50
	U-Value (W/m2K)	2.05	0.88	0.69	0.57	0.49
D: Internal Insulation	Thickness (mm)	0	20	30	40	50
Wall	U-Value (W/m2K)	2.05	0.88	0.69	0.57	0.49
Ceiling	U-Value (W/m2K)	2.25	0.96	0.74	0.61	0.51
Floor	U-Value (W/m2K)	3.44	1.12	0.84	0.67	0.56
E: External shading	Reach of sunshade (m)	0.00	0.07	0.13	0.26	0.39
	b/H	0	0.05	0.1	0.2	0.3
F: Glazing Performance	Type	Single Glass	Pair Glass	Pair Glass +	Low-E	Low-E +
	U-Value (W/m2K)	5.61	2.54	2.3	1.05	1.05
	G-Value (%/100)	0.83	0.44	0.30	0.33	0.22

H: Window height b: Reach of Shading

Default

Recommendation (from LOTUS)

Table. Levels distributed to each green building techniques

Results: Impacts of green building techniques on the thermal comfort under naturally ventilated condition

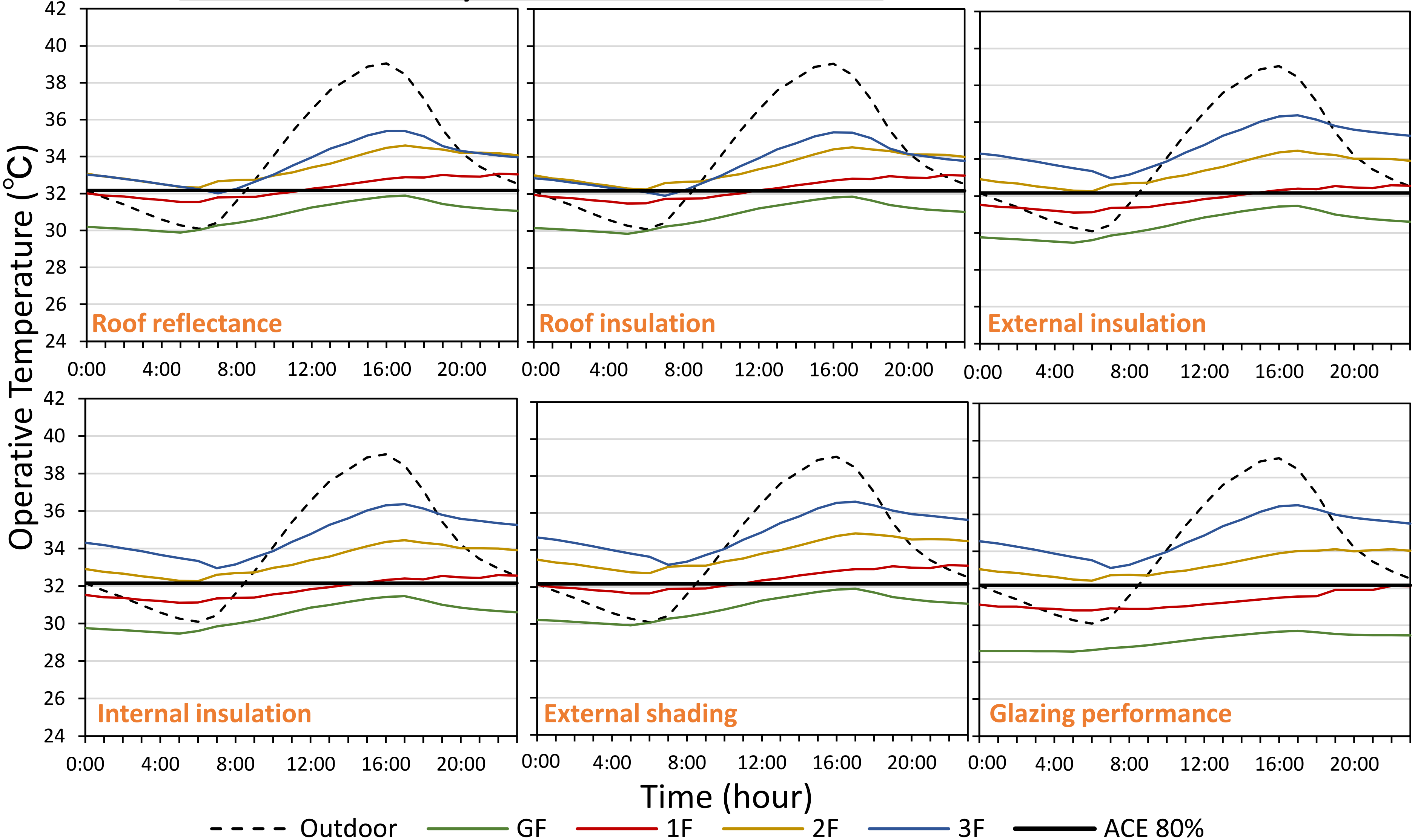


Figure. Outdoor temperature and indoor temperature for each floor with green building techniques in the case of Level 4 under night ventilation condition for existing urban area in future condition

Results: Impacts of green building techniques on the indoor temperature reduction in future condition

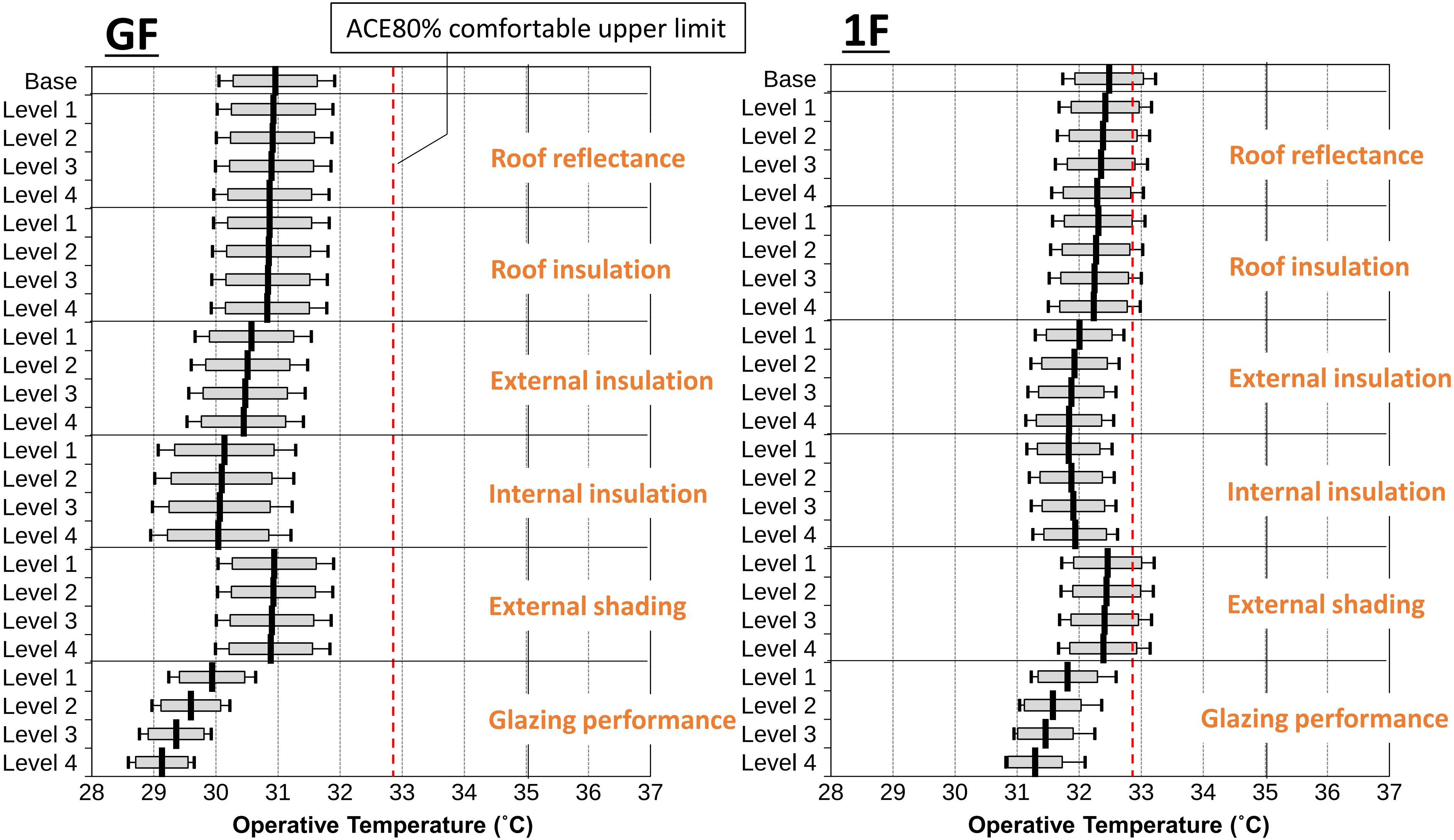


Figure. Thermal comfort evaluation of simulated indoor operative temperatures for each floor with green building techniques under night ventilation conditions for existing urban area in future condition

Results: Impacts of green building techniques on the indoor temperature reduction in future condition

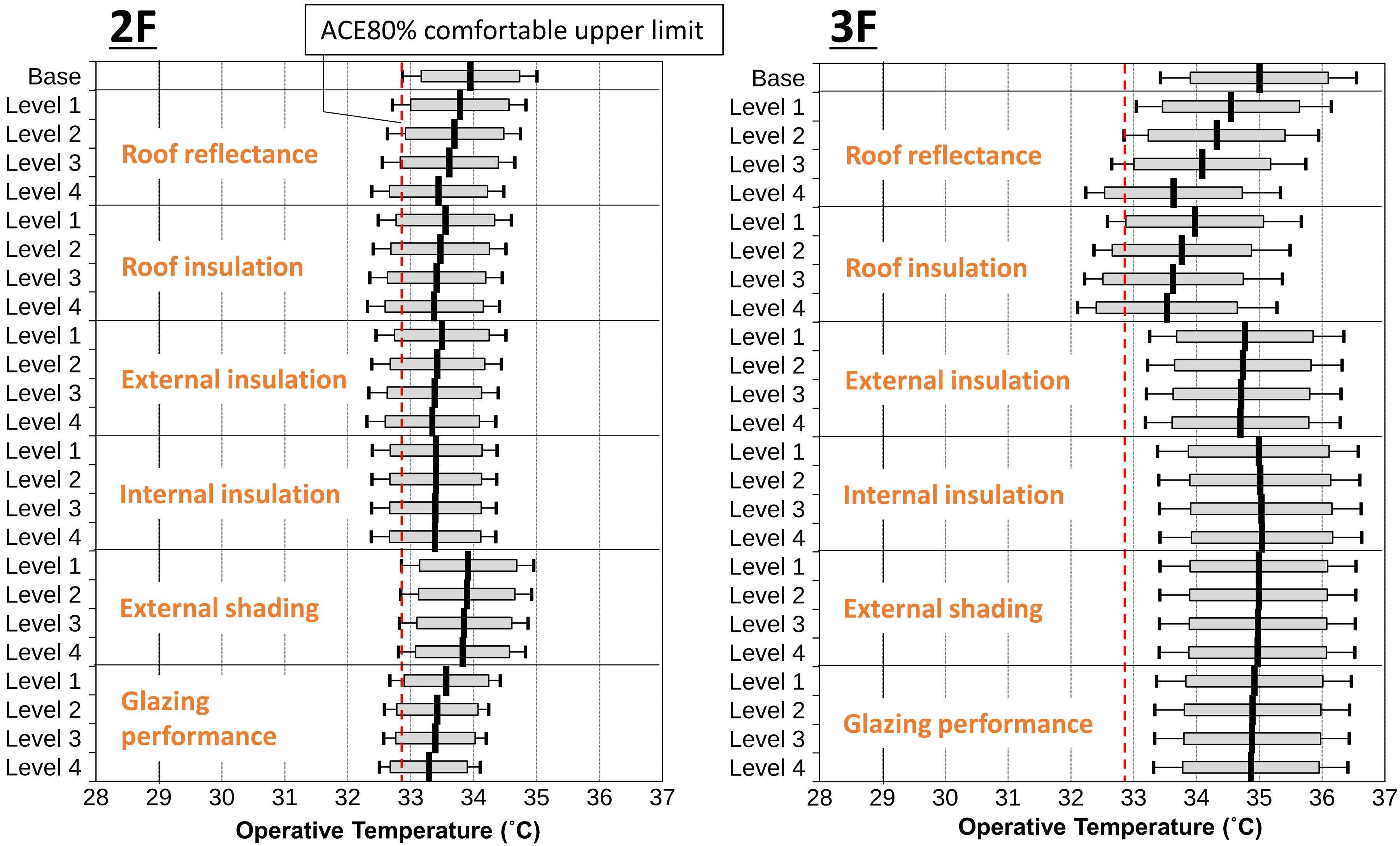


Figure. Thermal comfort evaluation of simulated indoor operative temperatures for each floor with green building techniques under night ventilation conditions for existing urban area in future condition

Results: Impacts of green building techniques on the cooling load reduction

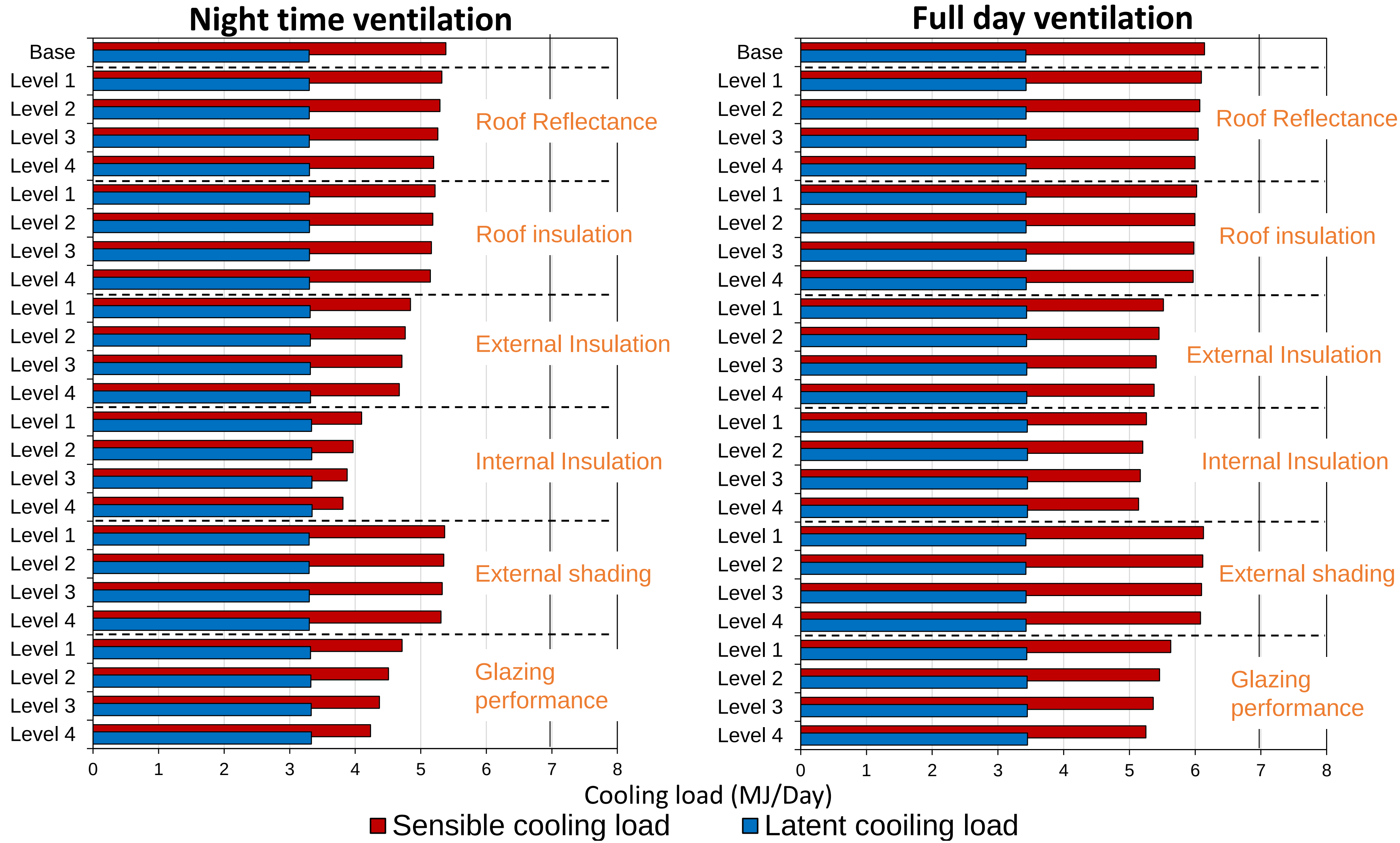


Figure. Cooing load of base and each level for single green building techniques in master bedroom for Night ventilation and Full day ventilation

AC setting (Set-Point temperature: 26°C Relative humidity: 60% Operating time: 8pm to 4am)

Conclusions

1. Night ventilation gives the largest reduction of operative temperature. Nevertheless, in the future climate, the exceeding period will increase even when the night ventilation is employed.

2. The glazing performance for windows gives the significant reduction of operative temperature in the master bedroom (0.8℃).

3. The cooling effect of the reflective roof and roof insulation on the indoor temperature is almost same. Reflective roof is more preferable since it can act as the countermeasure to the UHI.

4. The Installation of inside insulation for external wall under night ventilation were found to be effective green building techniques in reducing cooling load in master bedroom (29% reduction).